Phosphorus

Importance of Phosphorus

1. Constituent of many protein, co-enzyme, nucleic acids and metabolic substances.
2. Important in enzyme transfer.
3. Increases N-fixing nodule.
4. Stimulates seed formation.
5. Blooming and fruit setting.
6. Enhance development of plant.

Forms of Soil Phosphorus

Phosphorus present in the soil in the form of :-

1. Organic form.
2. Adsorb by clay surface.
3. As clay- Ca-$H_2PO_4^-$ Bridge.
4. Fixation by Fe, Al, Mn etc.
5. Precipitate compounds of Fe, Al or Ca.
6. Russel- Soil P divided into 3 forms-
    I. Soil Solution phosphorus.
    II. Inorganic soil phosphorus.
    III. Organic Soil phosphorus.

I. Soil Solution Phosphorus: Phosphorus is absorbed by plants largely as orthophosphate ($H_2PO_4^-$ and HPO_4^{2-}) ions which are present in soil solution. The amount of each form present depend on soil solution P^H.

At pH 7.2, there are approximately equal amounts of $H_2PO_4^-$ and HPO_4^{2-}. Below this pH, $H_2PO_4^-$ is the major form in soil solution where as HPO_4^{2-} is the predominant form above pH 7.2. Plant uptake of HPO_4^{2-} is much slower than $H_2PO_4^-$. Some low molecular weight soluble organic phosphorus exist in soil solution and may be absorbed but generally they are of minor importance.

The average 'P' concentration in soil solution is about 0.05 ppm and varies widely among soils. The

solution pH required by most plants varies from 0.003 to 0.3 ppm and depends on the crop species and level of production.

As root absorb phosphorus from soil solution, diffusion and mass flow transport additional 'P' to the root surface. Mass flow in low P soils will provide only a small portion of the requirement.

II. Inorganic soil Phosphorus

- Primary mineral from crop.
- Secondary mineral from primary or others.

Numerous inorganic compounds of phosphorus with Ca, Fe, Al, Mn, Mg, K etc. Most of them are not soluble and some soluble forms like ferrous.

Calcium (Ca) containing compounds are most important than others. The other original sources of 'P' is apatite { $3Ca_3(PO_4)_2$. Ca (Ca, F, $OH)_2$ }

Inorganic Ca compound of 'P' often found in soils. listed in order of increasing solubility.

Compounds	**Formula**
Flour apatite	$3Ca_3(PO_4)_2$. CaF_2
Carbonate apatite	$3Ca_3(PO_4)_2$. $CaCO_3$
Hydroxy apatite	$3Ca_3(PO_4)_2$. $Ca(OH)_2$
Oxy apatite	$3Ca_3(PO_4)_2$. CaO
Tri Calcium phosphate	$Ca_3(PO_4)_2$
Octa calcium phosphate	$Ca_8H_2(PO_4)_6$. $5H_2O$
Di Calcium phosphate	$CaHPO_4$. $2H_2O$
Mono calcium phosphate	$Ca(H_2PO_4)_2$

Fe, Al containing compounds in soil:

1. Strengite → $Fe(OH)(OH)(H_2PO_4)$

2. Varisite → $Al(H_2PO_4)(H_2PO_4)(H_2PO_4)$

3. Barindite → (Fe, Al) $PO_4.2H_2O$

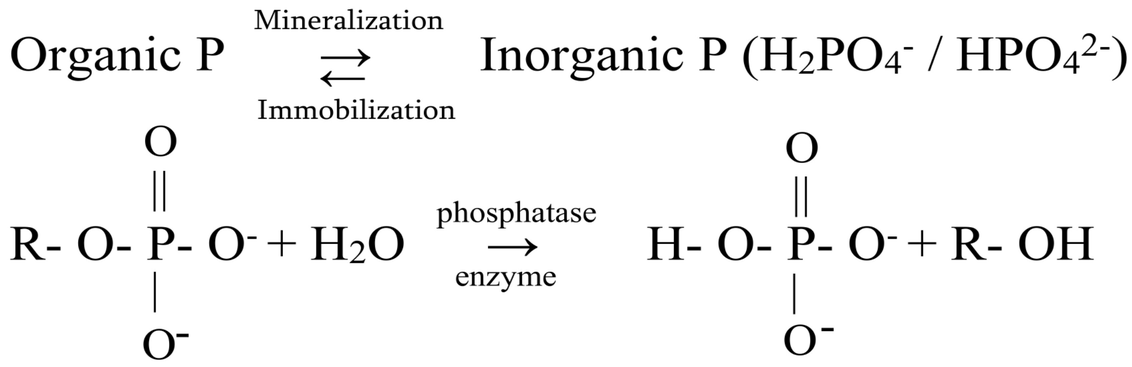
4. Duprenite → $Fe_2(OH)_2PO_4$

5. Woavellite → $Al_6(Fe_2OH)_6.9H_2O$

III. Organic Soil Phosphorus

Organic phosphorus represents about 50% of the total P in soils and typically varies between 15 and 80 % in most soils. The approximate proportion of those compounds in total organic 'P' is as follows-

i. <u>Insolitor P</u> →10-50 %. ii. <u>Phospholipids</u> →1-5 %. iii. <u>Nucleic acid</u> → 0.2-2.5 %.

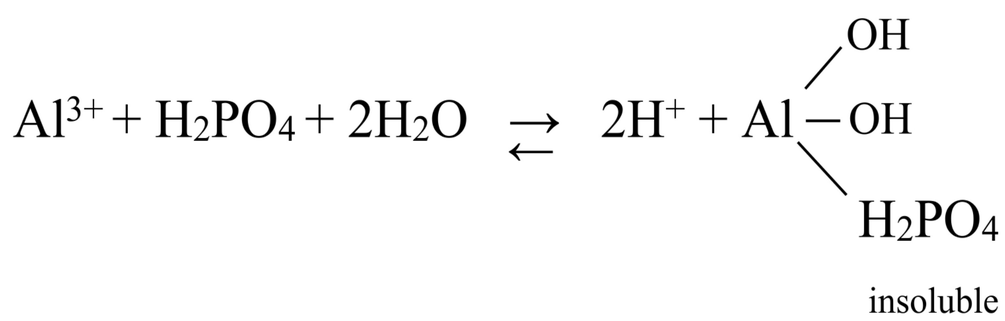


Like OM, soil organic phosphorus is decrease with depth. The mineralization of organic P depends on soil temperature, moisture, methods of cultivation nature or organic residues.

P-Fixation

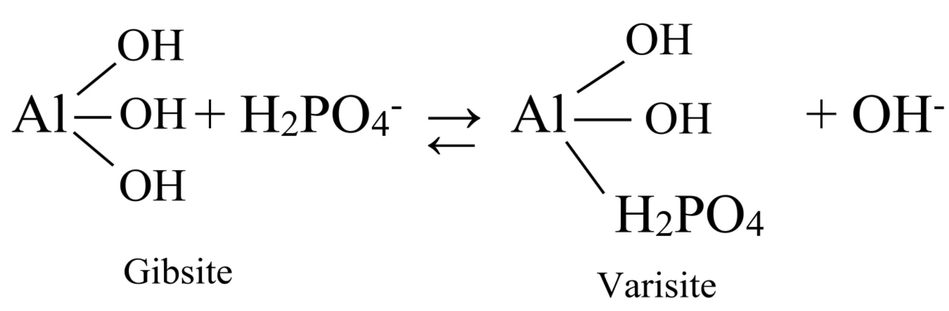
Available → Unavailable / less available.

A) Precipitation by Fe, Al, Mn ions-



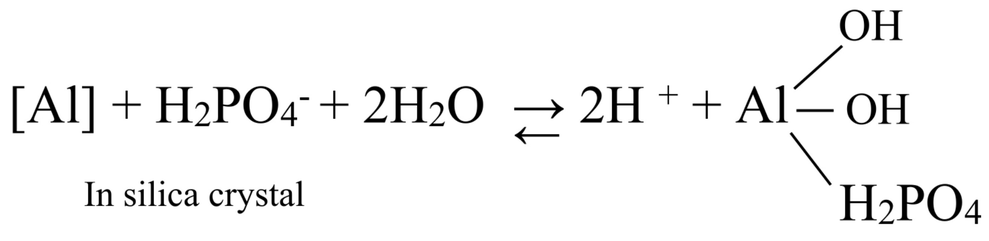
insoluble

B) Reaction with hydrous oxide-



Gibsite Varisite

C) Fixation by silicate clays-



In silica crystal

D) Anion exchange-

$$[>AlOH_2^+]OH + H_2PO_4^- \rightarrow [>AlOH_2^+]H_2PO_4 + OH^-$$

E) In alkaline or calcareous soils-

$$Ca(H_2PO_4)_2 + CaCO_3 + H_2O \rightarrow Ca_3(PO_4)_2 + CO_2 + 2H_2O$$

Clay- $Ca^{2+} \rightarrow H_2PO_4^-$ bridge

Factors affecting P fixation in soils

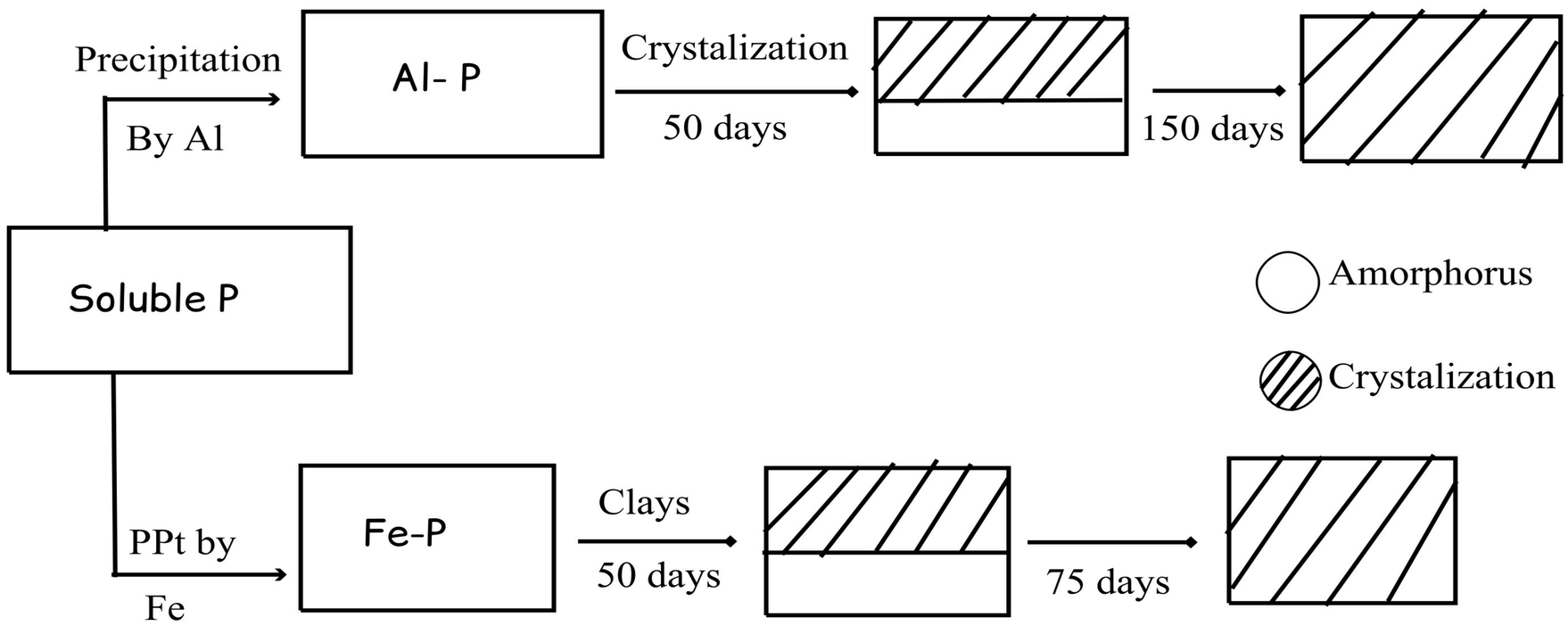
1. P-status in the soils: less P→ less fixation, More P→ more fixation. e.g. Red soil P fixation high.

2. Time of reaction: Initial fixation product→ Strengite/ Variscite.

↓

are amorphorus

So, slightly available to plants with the time 150-200 days they become crystalline and hence unavailability. Root can not take up crystalline form.

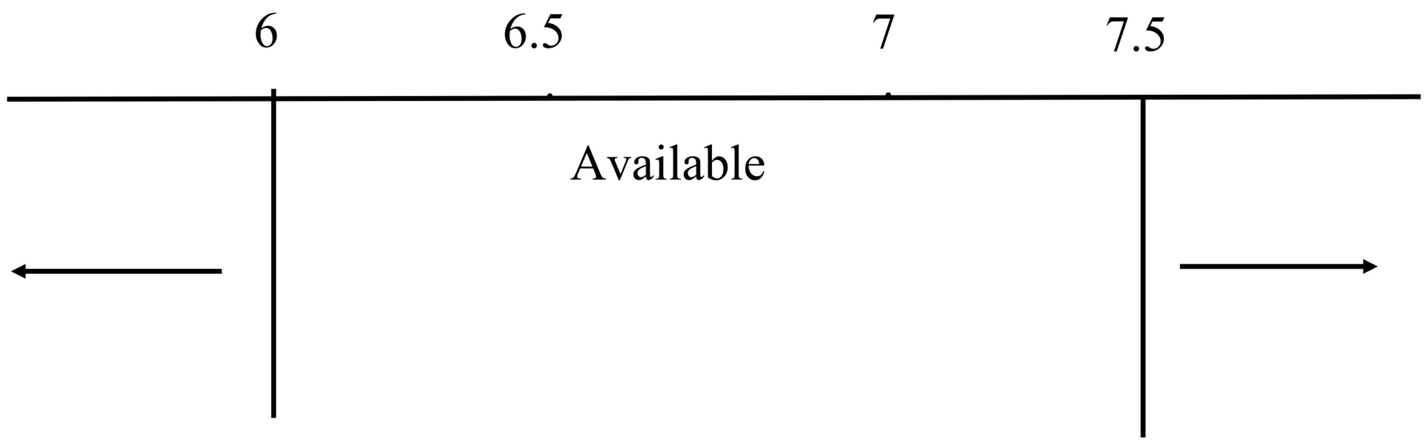


3. Temperature: If temperature increases, P also increases.

4. Moisture: In dry soil P- fixation more/ high and In wet soil P- fixation less.

5. Soil Reaction/ pH: In 6 and 7.5 pH, P-fixation less. < 6, P fixation less. 6 < , P fixation high.

Most suitable ranges of pH for P availability is 6.0-7.5 or 6.5-7.5 (around neutral).



- pH less than 6 → Fe, Al, Mn and their oxides and hydroxides fixation at lower pH.
- If pH 7.5-8.5 → Then Ca, Mg and their carbonates.
- pH 3-4 → In this condition will be highest condition.
- pH 2.5-3.5 → Maximum precipitation by ferric P.
- pH 3.5-4 → Maximum precipitation by Aluminium P.

6. Types of minerals: 1:1 type fixation more and 2:1 type fixation less.

7. Particle size: Fine texture → more fixation, Clay surface are more and active ions are more.

8. Exchangeable cations: Generally exchangeable cations increases P- fixation.

9. Effect of soils: Cl^-, CO_3^{2-}, HCO_3^-, SO_4^{2-} etc P fixation increase when these are large amount. The pH 6-7 increasing adsorption by KCl, K_2SO_4 decreases adsorption.

10. Organic matter: If organic matter increase, P fixation decrease. Organic matter plays an vital role in P-fixation in 3 ways-

i. ***Decomposition of Organic matter*** → CO_2

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 + \text{P- minerals} \rightarrow \text{Soluble P.}$$

(Insoluble)

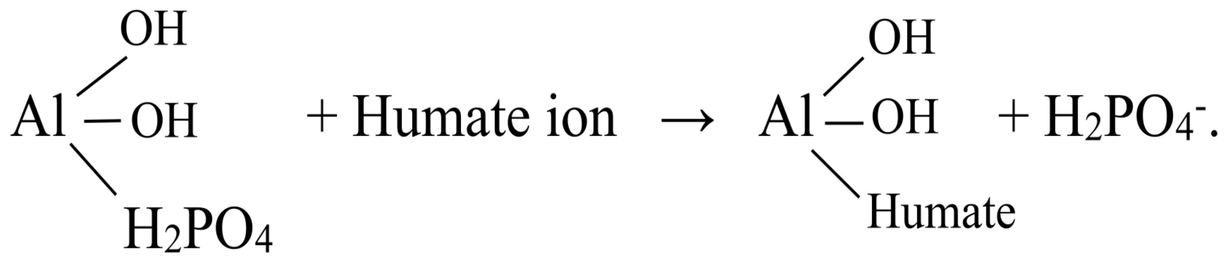
$$\text{e.g. } H_2CO_3 + Ca_3(PO_4)_2 \rightarrow CaHPO_4 + \text{---------}$$

ii. ***Decomposition of Organic matter*** → {Humic acid, Falvic acid}Humus.

a) Plant assimilate phospho-humic complex very easily-

$$\text{Humus} + P \rightarrow \text{Phospho-humic complex.}$$

b) Anion replacement by humate ion-

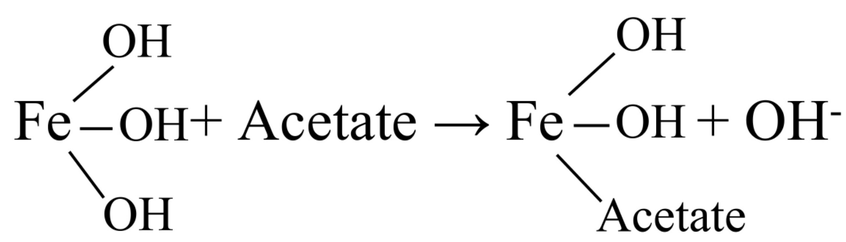


c) Forming a protective coating around sesquic oxide particles-

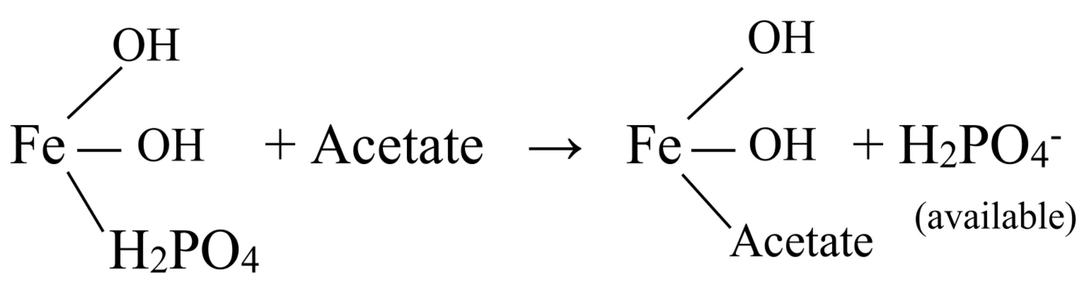
- Prevention of fixation of P by sesquic oxide.

iii. ***Organic Anions:*** Like acetate, citrate, lactate, oxalate, malate etc are formed by OM decomposition.

a) Anions react with Fe and Al forms stable complex so, P fixation is reduced.



b) Anions react with Fe and Al contain is fixed P and replace P as available form.



Phosphorus Cycle in soil